A New Class of Miniaturized Lightweight Highly Efficient Solid State Cryogenic Cooler, Phase I

Completed Technology Project (2018 - 2019)

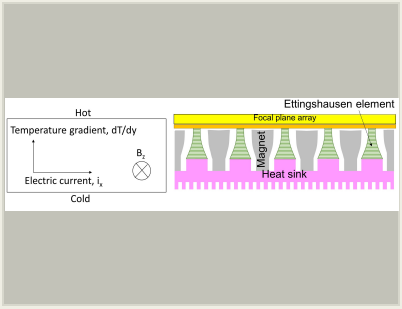
Project Introduction

A new class of solid-state, high-performance cryogenic coolers is proposed for space-based applications. Traditionally, cryocoolers for such applications have been Stirling or pulse tube refrigerators. These cryocoolers, although effective, are heavy, bulky, inefficient, and may cause vibrations. A high-performance solid-state cryocooler based on thermomagnetic cooling via the Ettingshausen effect can be lighter, smaller, vibration free, and use less power than the alternatives. Historically, the practical development of the Ettingshausen coolers was discouraged as they required a magnetic field difficult to reach by traditional ferrite magnets. However, recent rare-earth permanent magnets can produce the required field reliably. We propose an Ettingshausen cooler consisting of advanced permanent magnets combined with a novel semiconductor heterostructure predicted to significantly enhance the efficiency of the solid-state cryogenic cooling in a compact size. The Phase I work will demonstrate the preliminary materials properties and the design required to achieve cooling power larger than 0.2-0.3 W in 30-35 K temperatures ranges for the rejection temperature of 150 K, while consuming less than 5 W power. The grown heterostructure in phase I will be utilized for the manufacturing of a high-efficiency Ettingshausen thermomagnetic cryocooler in Phase II for specific applications in SmallSat or other micro platforms.

Anticipated Benefits

The III-V semiconductor-based thermomagnetic, solid state cryocooler will have wide ranging applications in both space and terrestrial systems. The cryocooler would immediately be applicable to many micro space platform systems, including SmallSat, where efficient, low power, and low vibration cryocooling is a necessity.

The Ettingshausen cryocooler can replace the less efficient or bulky coolers currently used in civil and defense systems including but not limited to the sensing of gamma and x-rays, medical imaging and procedures, superconducting systems, fluidics, and preservation. It will be smaller, lighter, more efficient, and consumes less power than current alternatives, and features no dangerous or expensive cryogenic liquids or moving parts which could cause detrimental vibrations.



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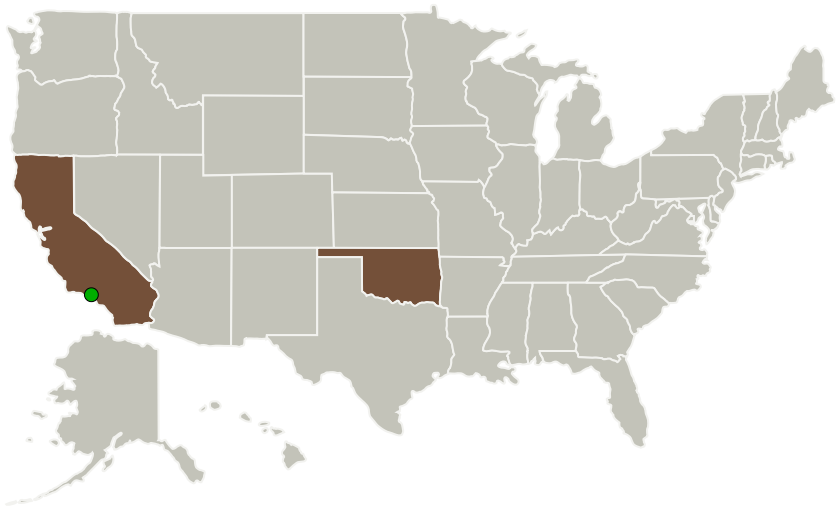
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Amethyst Research Inc.	Lead Organization	Industry Women-Owned Small Business (WOSB)	Ardmore, Oklahoma
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	Oklahoma

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141196)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Amethyst Research Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

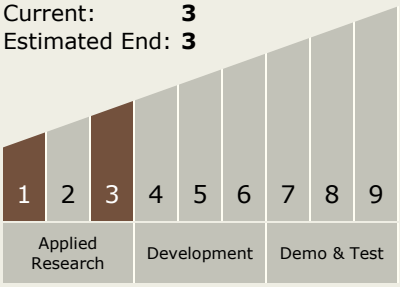
Carlos Torrez

Principal Investigator:

S. Ali Shojaee

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



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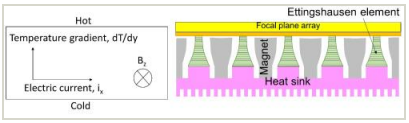
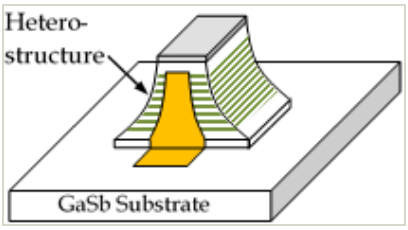
Images



Briefing Chart Image
A New Class of Miniaturized Lightweight Highly Efficient Solid State Cryogenic Cooler, Phase I
(https://techport.nasa.gov/image/134010)



Final Summary Chart Image
A New Class of Miniaturized Lightweight Highly Efficient Solid State Cryogenic Cooler, Phase I
(https://techport.nasa.gov/image/135643)

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.6 Cryogenic / Thermal

Target Destination

Earth